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(19)



(54) MANUFACTURING A HARDENED STEEL ARTICLE

(71) We, NORRBOTTENS JÄRN-
VERK A.B., a Swedish Body Corporate of
S-951 00 Luleå, Sweden, do hereby declare
the invention, for which we pray that a patent
may be granted to us, and the method by which
it is to be performed, to be particularly de-
scribed in and by the following statement:—

The invention relates to a method of manu-
facturing a hardened steel article, particularly
one with small wall thickness and good di-
mensional trueness.

For producing hardened and possibly tem-
pered thin details, for example of thin sheet
metal, preferably below 3 mm, with good
dimensional trueness, heretofore the detail after
having been formed in a conventional manner
was taken out of the forming apparatus, posi-
tioned in a holder to prevent subsequent dis-
tortion, and thereafter hardened and, possibly,
tempered. This procedure is complicated and
involves high requirements on the harden-
ability of the steel used.

The present invention provides a method
of manufacturing a hardened steel article, in
which a blank of hardenable steel is heated
to hardening temperature and thereafter placed
in a forming apparatus in which the blank is
formed to the desired final shape by being
subjected to substantial deformation and simul-
taneous rapid cooling, such that a martensitic
and/or bainitic structure is obtained while
the blank remains in the forming apparatus,
which serves as a gauge for preventing distor-
tion of the blank.

Preferably a blank of uniform thickness is
used, and preferably the thickness of the
formed article at any point differs from the
thickness of the blank by no more than 25%
of the thickness of the blank.

The steel utilized as starting material is pre-

ferably a boron-alloyed carbon steel or carbon
manganese steel. In order to obtain the desired
combination of hardness and toughness which
may render the tempering step unnecessary,
a steel may be used which contains, by weight,
less than 0.4% carbon, silicon in an amount
depending on the steel production method but
in general being insignificant, 0.5 to 2.0% man-
ganese, at maximum 0.05% phosphorus and
at maximum 0.05 sulphur, 0.1 to 0.5% chrom-
ium and/or 0.05 to 0.5% molybdenum, up to
0.1% titanium, 0.0005 to 0.01% boron, up to
a total of 0.1% aluminium and possibly in-
significant low contents of copper and nickel,
possibly in contents of up to 0.2% each.

Preferably the steel contains less than or
equal to 0.25% (preferably 0.15 to 0.25%)
carbon, silicon in an amount depending on the
steel production method but in general being
insignificant, 0.5 to 1.5% (preferably 0.7 to
1.5%) manganese, at maximum 0.03% phos-
phorus and at maximum 0.04% sulphur, 0.1 to
0.3% chromium and/or 0.05 to 0.5% molyb-
denum, 0.02 to 0.1% (preferably 0.02 to
0.05%) titanium, 0.0005 to 0.007% (prefer-
ably 0.0005 to 0.005%) boron, 0.03 to 0.1%
(preferably 0.03 to 0.07%) aluminium, and
possibly low insignificant contents of copper
and nickel, possibly in contents of up to 0.2%
each.

The steel is heated to hardening tempera-
ture, i.e. to a temperature above A_{c3} , where the
steel will be in austenitic state. The steel pre-
ferably is heated to a temperature between
775° C. and 1000° C.

The forming operation is preferably a press-
ing operation, but the method can also use
other forming techniques, such as drop forg-
ing, extrusion and explosive forming.

In the preferred pressing operation the blank

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Hot rolled or cold rolled and annealed state:

δ_S kp/mm ²	δ_B kp/mm ²	δ_5 %
36-42	50-60	23-55

(δ_S = yield stress, δ_B = ultimate tensile strength, δ_5 = elongation at fracture).

- 5 Hardened state: The following guide values are obtained, depending somewhat on dimension and hardening medium:

δ_S kp/mm ²	δ_B kp/mm ²	δ_5 %	Hardness	Toughness
			HRC	KCU 0°C kp/cm ²
120-150	150-170	8-12	45-50	5-10

- 10 (HRC = Rockwell 'C' hardness)
(KCU = impact energy, tested in accordance with ISO/R83).

15 With respect to their weldability, the boron-alloyed steels are to be judged after their base analysis, thus their carbon and manganese contents, because the structure attained in the heat-affected zone is not sensitive to hydrogen embrittlement. The boron steels listed in the

Table, therefore, can easily be welded as normal high-strength structural steels.

When the boron steel is to be welded prior to the forming and hardening, the properties of the base material after hardening can be attained also in the welding joint by using special electrodes adapted to the boron steels.

WHAT WE CLAIM IS:—

1. A method of manufacturing a hardened steel article, in which a blank of hardenable steel is heated to hardening temperature and thereafter placed in a forming apparatus in which the blank is formed to the desired final shape by being subjected to substantial deformation and simultaneous rapid cooling, such that a martensitic and/or bainitic structure is obtained while the blank remains in the forming apparatus, which serves as a gauge for preventing distortion of the blank.
2. A method as claimed in claim 1, in which the blank is heated to a temperature above A_{C_1} .
3. A method as claimed in claim 2, in which the said temperature is between 775°C . and 1000°C .
4. A method as claimed in any of claims 1 to 3, in which deformation and cooling are carried out so rapidly that a fine-grain martensitic and/or bainitic structure is obtained.
5. A method as claimed in any of the preceding claims, in which forming is carried out between two tools, which are pressed together rapidly.
6. A method as claimed in any of claims 1 to 4, in which forming is carried out against one tool by means of a pressure medium.
7. A method as claimed in any of the preceding claims, in which the rapid cooling continues after deformation has been completed, the blank remaining in the forming apparatus.
8. A method as claimed in any of the preceding claims, in which cooling is effected by cooling parts of the forming apparatus.
9. A method as claimed in any of the preceding claims, in which cooling is effected by contacting the blank directly with a coolant.
10. A method as claimed in any of the preceding claims, in which the blank is of uniform thickness.
11. A method as claimed in claim 10, in which the thickness of the formed article at any point differs from the thickness of the blank by at most 25% of the thickness of the blank.
12. A method as claimed in any of the preceding claims, in which the hardenable steel contains, by weight, less than 0.4% carbon, 0.5 to 2.0% manganese, at maximum 0.05% phosphorus and at maximum 0.05% sulphur, 0.1 to 0.5% chromium and/or 0.05 to 0.5% molybdenum, up to 0.1% titanium, 0.0005 to 0.1% boron, and up to 0.1% aluminium; the balance being iron and impurities including silicon.
13. A method as claimed in claim 12, in which the steel contains, by weight less than or equal to 0.25% (preferably 0.15 to 0.25%) carbon, 0.5 to 1.5% (preferably 0.7 to 1.5%) manganese, at maximum 0.03% phosphorus and at maximum 0.04% sulphur, 0.1 to 0.3% chromium and/or 0.05 to 0.5% molybdenum, 0.02 to 0.1% (preferably 0.02 to 0.05%) titanium, 0.0005 to 0.007% (preferably 0.0005 to 0.005%) boron, and 0.03 to 0.1% (preferably 0.03 to 0.07%) aluminium.
14. A method of manufacturing a hardened steel article substantially as described herein with reference to the Example.
15. A hardened steel article manufactured by a method according to any of the preceding claims.

MARKS & CLERK.